Digitally supporting the co-creation of future advanced services for 'Heat as a Service'

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DIGITALLY SUPPORTING THE CO-CREATION OF FUTURE ADVANCED SERVICES FOR 'HEAT AS A SERVICE'

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ABSTRACT

Purpose: This paper is a preliminary exploration of how a digital prototype might be developed to support co-creation in developing future advanced services for 'Heat as a Service' (HaaS).

Design/Methodology/Approach: A user-centred design approach was undertaken with two customer segments to establish potential requirements for HaaS. A systems thinking approach was then used for the preliminary development of a digital tool to support new advanced services.

Findings: Further definitions of HaaS from the perspective of two different customer segments are presented, with emerging proposals on (i) how they can be managed in a system setting and (ii) suitable supporting digital tools.

Originality/Value: A user-centred approach to new advanced services development is presented to take into consideration current and future engineering and digital capabilities, moving beyond a conventional product-centric service development approach.

KEYWORDS: Advanced services, user-centred design, digital twin

1. INTRODUCTION

Advanced services are the provision of outcome-based solutions, creating a risk and value sharing partnership between the customer and the supplier. Advances in digitalized technology create an opportunity to increase the scope of such advanced services, whether this be through the addition of smart technology into the service itself, or the use of digital techniques to model and explore new advanced service concepts. An example of an advanced service is the move towards providing heat in the home as 'Heat as a Service' (HaaS), based on the provision of thermal comfort, rather than the payment of physical products and units of energy. For a manufacturing organisation looking to move into the provision of advanced services in this area, there are challenges in translating the HaaS concept into a range of flexible solutions to suit wide ranging customer needs and expectations. Digitalized methods to support and create opportunities for novel advanced services through co-creation therefore require further investigation.

This work is part of a larger multi-disciplinary project that takes a customer-focused perspective to develop a better understanding of the HaaS concept. This understanding will then be used to design a digital prototype to digitally map the future services, providing an environment for service co-creation to occur. This paper specifically reports on the preliminary findings of the user-centred design approach with customer preferences reflecting potential advanced service opportunities. A systems thinking approach is then taken to explore the digital resources available to support the prototyping of new advanced services to meet these preferences. The concept for a digital prototype to support this is then presented.

2. BACKGROUND

Advanced Services are a type of servitization that deliver customer value based on outcome rather than ownership; sharing risk, revenue and value (Musson et al. 2019). Such business models are being adopted by manufacturing organisations to widen the scope of their customer offerings to offer a mix of products and services (Kowalkowski, Gebauer and Oliva, 2017). Advances in digitalized technologies offer significant opportunities to such organisations, in that they can be exploited to increase the scope of potential services offered both within the existing product in use (i.e. condition monitoring), and those not embodied in the product definition and / or of higher value (Coreynen et al. 2017, Chowdhury et al. 2018).

HaaS is an example of a potential advanced service. Rather than paying for units of energy delivered (i.e. KWH), customers pay for units of experience, in this case, the provision of 'warm hours' or 'smart thermal comfort', often delivered via smart systems (Energy Systems Catapult 2019). The drivers for HaaS lie in the decarbonisation of UK home heating, more efficient energy provision and providers seeking more consistent revenue streams. However, delivering HaaS presents a series of challenges both to the energy provider and the network of organisations that provide various parts of the infrastructure for delivering such a service. Examples are: the range of property types and ages, and their varying efficiencies, particularly for existing housing stock; and the range of users of such HaaS systems and their own individual circumstances, requirements, and behaviours towards the system (Energy Systems Catapult 2019). The Energy Systems Catapult highlights '3Cs' (Comfort, Control and Convenience)' as key customer requirements for an acceptable alternative to their current (often gas-fired) systems (2019). Delta-EE have highlighted five risks normally borne by the customer that would need to be transferred to the supplier in order to deliver HaaS. They are financial, technical, performance-related, behavioural and energy price fluctuations (Delta-EE 2019). Organisations operating in this environment, therefore, need to know how and where they will contribute to the new HaaS value chain, and develop capabilities to ensure they can deliver value (Bustinza et al., 2015). Essentially the customer is defining the value to be added but flexibility is needed to both understand what this value might look like and understand how, as a network of providers in a value chain, these organisations respond. Thus, in defining what a new advanced services to deliver HaaS might be, a method that involves customer co-creation activities is clearly advantageous.

It is worthwhile examining current digital approaches that could be used in the development of advanced services. Digital modelling approaches, particularly digital twins, are being increasingly developed to support the introduction of new products and services into the marketplace. Kritzinger et al. (2018) distinguish between three stages of digital modelling (digital models, digital shadows and digital twins), depending on the level of interaction between the physical model and the virtual model. With a digital twin, there is a real-time connection between both spaces with updating in both directions (Kritzinger et al., 2018). However, this real-time, two-way interaction is most developed through product in-use or operation data and represents a challenge for the early stages of concept product design due to the availability and uniformity of the data (Jones et al 2019). Ströer et al. (2018) discuss how most service-related data is generated during use and fed back for product design. In the absence of such data, simulation and machine learning can be used to predict the data required and inform the design progression.

In terms of design methods utilising digital modelling, the dominant approach is an extension of product lifecycle management, so that new developments are primarily product-centric, and services support the existing product in use. The emphasis is on the efficient integration of data across each stage of the product lifecycle. As an example, Tao et al. (2018) considered a product-centric digital twin approach that spanned across all stages of product lifecycle management, with the primary aim of improving the efficiency of data integration across each stage. The purpose of adding value through services (servitization) was not acknowledged, only services related to maintaining the product in use. However, the integration of customer data was acknowledged as a requirement during the concept stage of design and the digital twin presented as a suitable means of integrating this. Zheng et al. (2018) also presented the potential of a digital twin as an enabler for smart service innovations due to its linking of physical and digital spaces. They demonstrated this with a smart product service system, using wearable technology (a respirator) as an example. An opportunity for designing new service opportunities around the data generated from its use was highlighted. Hence, there was an opportunity for the value in services to transcend those directly related to the product and the scope of the digital twin was increased. Furthermore, Rambow-Hoeschele et al. (2018) extended the scope of a digital twin beyond the scope of the physical product to business models, creating a digital model builder, which encompassed elements of product, service and value offering modelling from a business modelling perspective. This was defined as a digital twin due to the real time exchange of data between the physical and virtual spaces.

An opportunity, therefore, exists to consider in detail, the generation and use of customer user data for the co-creation of digitally enhanced advanced services, focusing on a HaaS solution. A digital approach is required that enables an organisation to explore potential advanced services and capabilities to respond, but without tying this to a conventional product-centric design approach.

To investigate this further, a two-stage study design approach was adopted. Study 1 was a user-centred design approach to understand the end user perspective and uncover future potential service opportunities for HaaS. These were then used to inform study 2, which used a systems thinking approach to explore potential digital prototyping opportunities. These studies are reported in the next two sections respectively.

3. STUDY 1: THE DESIRED USER EXPERIENCE FROM TWO PERSPECTIVES

3.1 Approach and Study

In the context of everyday tasks, user-centred design can be considered to offer both a philosophy and a process (Haines and Mitchell, 2013). The philosophy is that design should focus on the needs of the user as a central tenet, seeking to ensure that the needs and wants of users are considered throughout the process (Norman, 1998). The process is characterised by an early focus on users and tasks (Gould and Lewis, 1985) and stresses the importance of user goals, behaviours, contexts, characteristics and decision-making (Sharp et al. 2007). User-centred design is widely accepted as leading to the design of useful, usable and desirable products, services and systems.

The user-centric design approach was taken to uncover future opportunities and requirements for the heat as a service concept. Two key end-user groups were identified in collaboration with the focal manufacturer: householders and social housing landlords. These groups were selected in order to explore two diverse scenarios of use to take forward into the next phases of research.

The first group comprised 15 householders with the following characteristics: a mix of owner-occupier and rental with 1-5 occupants; 6 male and 9 female; predominantly gas boilers plus a range of additional heating or log burners; some with smart meters or intelligent thermostats; and a range of attitudes to technology. A participatory design approach was used to take the householders through 3 stages of a semi-structured interview: (i) sensitisation to the context (describing their current heating situation and experiences); (ii) a design fiction ("your heating is stripped out and you have your own 'thermal comfort PA' what would they need to know and what could they do for you?"); and (iii) idea-generation, based on (ii) and exploring three main phases of the personalised thermal comfort 'system' - planning, using, and leaving (e.g. moving house). All sessions were audio recorded, transcribed and subjected to a thematic analysis to extract the key functional and experiential needs.

The second group comprised social housing landlords. These are an interesting use case since they act as an intermediary between equipment and service suppliers and the end consumer. Social landlords provide rented housing to selected community groups (including vulnerable sectors) and are responsible for providing a tenancy service that enables good value, comfortable and healthy living (legal requirement) environments. Two large social landlord organisations based in the UK took part in the study – large organisations were chosen as they have a wide range of staff with various roles and technical expertise, and can provide a multi-disciplinary contribution to service-related insights centred around heating. A total of eight staff took part in two semi-structured discussion groups, each lasting about one and half hours. The specialisms of the staff within these organisations were as follows: new technology and innovation, technology and process transformation, operations management, customer service, and external and internal communications. The discussions followed the approximate format of: research background, consent and ethics, introductions, key measures of success, problems they face, needs they have, new ideas to meet needs and capitalize on opportunities, paths and barriers relating to implementation. A range of user and service focussed tools were used including stakeholder and customer journey mapping, as preferred by the participants.

3.2 Results

The results from the householder interviews elicited some key high-level insights. Firstly, there was a wide variation in needs and wants, influenced by factors such as personal comfort preferences, occupants (e.g. babies, visitors), schedules (daily, weekly, annual) and attitudes to technology and data usage. In addition, participants varied in their prioritising of what we have identified as the '5Cs' – comfort, control, convenience, cost and carbon-reduction (with the latter two factors adding to the three identified previously (Energy Systems Catapult, 2019). Results based on the three main phases of the personalised thermal comfort 'system' (planning, using, and leaving) indicated what knowledge/data the 'thermal comfort PA' would need to access and are presented in Table 1.

Table 1. Knowledge and actions required for the 'thermal comfort PA'

Planning	Using	Leaving
Occupants Personal temperature preferences (un)known Household routines (or lack of) & exceptions Room usage level and activity/function Priorities ('5Cs': comfort, convenience, control, cost and carbon-reduction) House structure, insulation, decoration, sun location Aesthetic	Moving in and out of house Moving around house Instantaneous heat when enter (room/house) Room-by-room variation Privacy of schedule/activity data (wide variety of opinions) Automation? But with user control, awareness, assurances Learning then stabilising + user intervention Reports, hints & tips, to 'help the grid'	Take my profile with me Adjust to new home/schedule/occupants Need to re-coup my investment What data do I leave behind? 'take the brain!' How would it work re the 'supplier'? Chance for complete transformation e.g. Passive House Reduce the stress!

The results from the social housing landlords focused on generating some specific service concepts that would meet their needs in relation to 'heat as a service' provision to tenants. Table 2 gives an outline of the ten service concepts (SC1-SC10) generated with the Social Landlords, together with the key features for service interaction. They are shown in a temporal order that relates to key touchpoints and processes on the customer journey from SC1 to SC10 of a social housing tenant, and include some specific, and other more general, and future focussed concepts.

Table 2. Service Concepts and Key Features for Social Housing Landlords

Service concept	Key features
SC1 -Getting the gas and heating up and running for the customer	An advisory/intelligent system/liaison type service that guides the tenant through this process
SC2 -Managing access around the annual gas safety check	Opening up communication channels with the tenant and scheduling inspection visits based on engineer locations and availability
SC3 -Diagnosis/resolution of heating problems	A single, manufacturer agnostic, diagnostic dashboard that can be used by the customer service team in conjunction with the engineering team, it sends back fault data from the boiler to enable remote fault finding and diagnosis.

Table 2. Continued

Service concept	Key features
SC4 -Predictive boiler performance and preventative maintenance	A predictive tool that enables the landlord to identify when a boiler is starting to work non-optimally, and flags this up to the landlord for maintenance
SC5 -Optimising the thermal performance of the housing stock	A service that does an audit on each landlord property, and recommends to the landlords a variety of retrofit options with alternative costs and benefits profiles.
SC6 -Using data to 'look after' the customer	A tool that enables a landlord to identify tenant behaviours which are contrary to good wellbeing, centred around heating, but could extend to broader safety and wellbeing.
SC7 -The (healthy, enabling) connected home (link with above)	Service solutions around the 'connected home' using a portal and heat and other sensor data.
SC8 -Managing the transition away from gas boilers (the future limits on installing gas-fired boilers into new properties)	An educational service, aimed at enabling social landlords, customers and heating manufacturers to understand and develop future heating solutions
SC9 -Provision of 'warm hours'	Centralised heat provision, tailored service plans, hot-swappable provision
SC10 -Maximising organisational operational efficiency	A service that maximise operational efficiency for the social landlords based on optimising trade-offs between: customer (internal and external) satisfaction; operational efficiency; compliance; future proofing; environment concerns.

4. STUDY 2: PRELIMINARY STUDY OF SUPPORTING DIGITAL TOOLS

In terms of the method by which new advanced services developments could be investigated, and requirements understood, a Systems thinking perspective was adopted. In this context, systems thinking can be defined as a '*framework for seeing wholes and interrelationships*' (Arnold and Wade, 2015). Systems thinking involves looking entirely at the bigger picture while understanding the relationships between all the separate parts and how they work together. Systems thinking can be applied by understanding the system of interest, its inherent and emergent behaviour while trying to reduce complexity through modelling (Kossiakoff et al. 2011). Systems thinking is important in this context, as the HaaS solution will necessitate a multi-stakeholder collaboration in order to deliver a variety of systems and services and, therefore, it is important to consider the socio-technical capabilities that each organisation will need to deliver, and to whom, as the beneficiary of the service or system. In other words, the 'end-user' or customer of one system, may well be the service provider to the end-user of the HaaS experience, i.e. the occupant. Additionally, this creates an environment where potential solutions can be explored without them being tied specifically to an existing or new product proposal. Therefore, the full scope of advanced services – and the capabilities required to deliver them – can be investigated.

From the end-user insights indicated in Table 1 and Table 2, a preliminary exploration was conducted using the systems thinking approach. The system key elements were first identified from six dimensions including human players, machine (equipment), services (already identified in the user perceptions data), data, service tools and the system structure. The human players include householders, landlords with their tenants, and service providers (in/outside of the manufacturer). The machine includes all individual heating equipment, each with a unique product ID and embedded sensors for receiving instructions or sending product running data/information to the system via IoT for SC3-5. Data includes user-generated data, machine-generated data and service generated data. Examples of user-generated data include occupants' profiles and behaviour data for SC1 and 6, the machine-generated data includes machine-specific faults and performance data to support SC3 and 5, and the service generated data includes third-party service providers' generated data, such as problem diagnostic data and gas inspection data for SC2 and 3. The service tools include service advisory tools for SC1 and 5, communication tools in SC2, predictive tools in SC4 and 6, and educational tools in SC 8.

A digital twinning platform is now being explored as the system backbone, with a front-end as a web app and the back-end as a web service, to integrate all system key elements together and through incrementally digital twinning processing, eventually make it an ecosystem. The system structure is illustrated in Figure 1, outlining the key interactions and enabling tools that will be required.

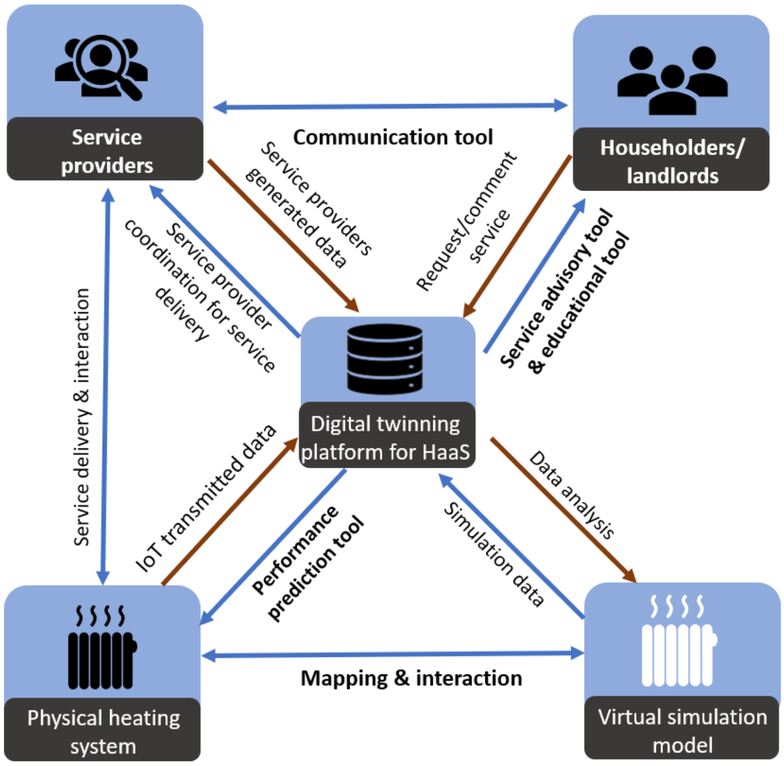

Figure 1: Key interactions and enabling tools on HaaS digital twinning platform.

The key to developing a digital twinning platform is to connect heating devices and key system players to the platform and to implement platform enabling tools, providing householders, and social landlords and their tenants, an easy way to get their requested services delivered in a timely way, thus, bringing them a better user experience. In turn, with more data (the red arrows in Fig. 1) adding to the platform, the simulation model gets more accurate over time, making the platform more reliable in delivering high-quality digital heating services and in providing data to help shape/upgrade heating devices and services in the future.

An early stage demonstrator for the platform, with simulation, is now being considered. A small selection of the key service concepts from those identified in table 2 will be selected and used to design and prototype the supporting tools in the demonstrator. The aim of this work will be to demonstrate and evaluate the principle of digital twinning technology for advanced services.

5. CONCLUSIONS

In this work, we have investigated how digitalization can support the development of new advanced services within the HaaS environment by capturing customer requirements and feedback. Potential opportunities for Haas developments were explored with two customer segments to generate a deeper understanding of the desired user experience. Following on from this, a digital twin platform approach, using simulation, is being used to prototype a demonstrator for evaluation on two accounts. The first is to evaluate how desired user experiences can be used to explore future advanced services opportunities. The second is to evaluate the digital twin platform to explore opportunities in advanced services development beyond the product-centric approach, and the suitability of its application at the concept stage.

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